

# *NREL's Outdoor Test Facility*

*...advancing photovoltaic technology*

Since the 1980s, when U.S. photovoltaic companies wanted independent testing of prototype solar cells, modules and systems, they turned to the National Renewable Energy Laboratory's (NREL) Outdoor Test Facility (OTF). OTF's state-of-the-art laboratories, outdoor test beds and support services are annually used to test the performance and reliability of over 3,500 photovoltaic cells and modules fabricated by NREL researchers and industry partners.

These testing activities help companies reduce photovoltaic costs and improve performance, reliability and safety. And with a new 10,000-square-foot laboratory building, the federal government's premier photovoltaic testing facility just got better.

## *What is Photovoltaic Technology?*

Photovoltaic devices, commonly called solar cells or modules, use semiconductor material to directly convert sunlight into electricity. Photovoltaics are used to power remote residences, satellites, highway emergency call boxes, highway traffic and information signs, water pumps, street lights and calculators. U.S. electric utilities also use photovoltaic systems to provide electricity to customers.

## *Outdoor Test Facility*

Researchers at the OTF evaluate advanced photovoltaic technologies under simulated, accelerated and prevailing outdoor conditions to verify performance and improve engineering development. The new laboratory building consolidates these activities in one location and provides improved and expanded testing and characterization capabilities.

Simulated and accelerated testing is conducted in eight laboratories housed within the new building. In a controlled setting, researchers simulate outdoor conditions to analyze how photovoltaic devices perform under prolonged exposure to extreme weather conditions. A field adjacent to the laboratory building is used for actual outdoor testing.



## *Indoor Laboratory Testing*

**High Bay Test Laboratory**—Large chambers in the high bay area are used to determine how modules perform when exposed to varying outdoor weather conditions such as heat, cold, humidity, moisture and ultra-violet light. Mechanical tests include flexing modules 10,000 times at different angles, and firing one-inch diameter ice balls at modules at an impact velocity of 52 mph to simulate hail strikes.

**Large Area Solar Simulator Lab**—Characterization of large-area modules is conducted in a laboratory painted black to prevent reflection of light. Module characterization is performed to determine electrical output performance. The laboratory

contains both a pulse and continuous solar simulator to measure module conversion efficiency, which is the amount of sunlight the module converts to electricity.

The pulse simulator uses rapid, short bursts of light to measure performance without heating the module. The continuous simulator uses a steady light source that more closely resembles sunlight. Both simulators are needed to fully characterize modules.

**Exploratory Diagnostics and Failure Analysis Lab**—Modules are tested in high voltage and wet conditions to evaluate electrical insulation and verify that moisture will not enter the module and cause corrosion, ground faults or pose an electrical safety hazard. In one test, modules are submerged in water, then subjected to elevated voltages ranging from 2000–3000 volts to see if the module is vulnerable to water leakage.

Researchers in this lab also perform other forms of nondestructive, destructive and accelerated testing to determine what causes module and system failure. This knowledge is used to improve module and system reliability.

**Outdoor Test and Measurement Lab**—Researchers in this laboratory monitor and analyze data received from modules and systems tested outdoors.

**Other Laboratories**—Other laboratories are used to prepare cells, modules and systems for testing and outdoor deployment, and for developing, characterizing and evaluating solar simulators and related equipment.

### *Outdoor Testing*

At the outdoor field site adjacent to the laboratory building, more than 100 modules and six systems are being tested and evaluated for performance, reliability

and electrical output. NREL also monitors two, 6-kilowatt systems mounted on the nearby Solar Energy Research Facility (SERF).



The two systems at SERF and five of the six systems at the OTF are connected to the local utility grid, providing NREL with valuable real-world experience under actual utility conditions, and the utility with 18 kilowatts of electricity.

### *Setting Standards and Codes*

Researchers at the OTF also work with industry to set uniform and consensus standards and codes for testing photovoltaic devices. This work provides guidelines for test methods and design techniques by establishing specific steps or criteria to follow when testing or designing photovoltaic modules or systems.

### *Innovative Systems Under Test*

Researchers at the OTF are testing innovative PV designs including PV roofing systems, area lights, walkway lights, and PV-covered carports for recharging electric cars.